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PRELIMINARY CALIBRATION TRIALS OF A SOLINST LOAD CELL USING THREE DIFFERENT LOADING CONFIGURATIONS

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PRELIMINARY CALIBRATION TRIALS OF A SOLINST LOAD CELL USING THREE DIFFERENT LOADING CONFIGURATIONS

by

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SUMMARY

In February 1984, an instrumentation scheme was proposed to monitor the infilled behaviour of a large cavity which resulted from two consecutive outbursts in the No. 26 Colliery Main Deeps. The proposed instrumentation scheme essentially involved the installation of extensometers and load cells within the cavity support system. However, because the cavity support system had already been installed, questions were raised concerning the validity of mounting load cells in essentially point load configurations. A series of calibration trials were therefore undertaken and this report describes and presents the results of those tests along with recommendations for future work.

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CALIBRAGE PRÉLIMINAIRE D'UNE CAPSULE DYNAMOMÉTRIQUE SOLINST EN UTILISANT TROIS CHARGES DIFFÉRENTES.

par

T.R.C. Aston

RÉSUMÉ

En février 1984, on a élaboré un projet d'instrumentation pour le monitorage du remblai d'une grande cavité résultant de deux dégagements instantanés dans la houillère n° 26. Le projet d'instrumentation comprenant principalement l'installation d'extensomètres et de capsules dynamométriques à l'intérieur du mode de soutènement de la cavité. Cependant, le mode de soutènement ayant déjà été installé, on a remis en question l'utilité de monter des capsules dynamométriques dans des configurations essentiellement de charges ponctuelles. Ce rapport présente une description des essais et des conseils portant sur les travaux futurs.

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INTRODUCTION

In February 1984, an instrumentation scheme was proposed to monitor the infilled behaviour of a large cavity which resulted from two consecutive outbursts in the No. 26 Colliery Main Deeps. Figure 1 shows the proposed instrumentation which involves the installation of extensometers and load cells within the cavity support system (wooden cribs).

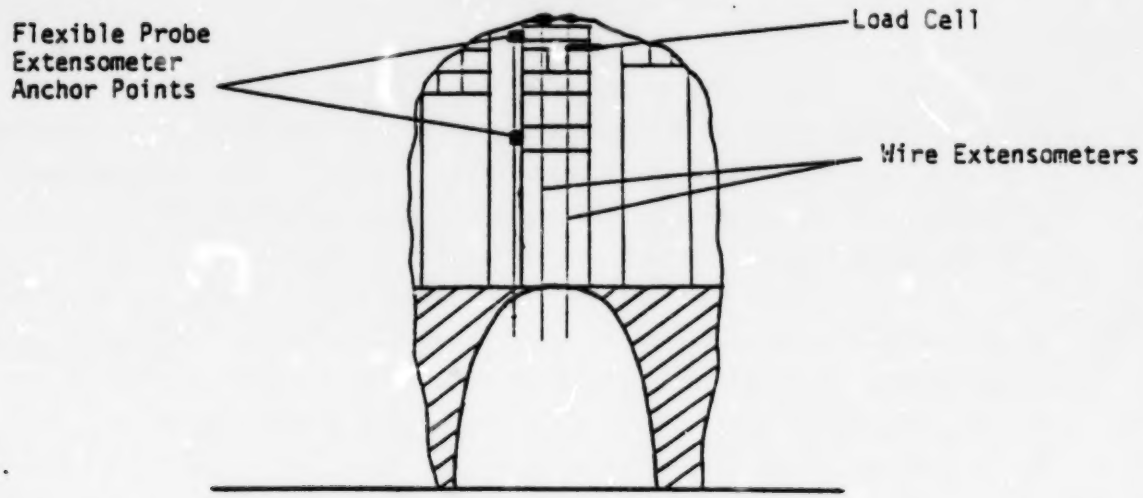
Previous work by CBCRL staff (1) using Solinst load cells involved installing them between two solid wood layers formed in the crib during construction. To avoid point loading and facilitate a more uniform distribution of the load, the cell was embedded in a thick layer of stone dust. However, wooden cribs had already been installed in the No. 26 Deeps cavity and the subsequent dismantling and installation of solid wood layers would have proved impractical. Two alternative methods of installing the load cells were therefore considered:

1) Remove the upper most crib block and insert a load cell at the corner, Figure 2.
2) As 1), except insert the cell between two 12 mm thick steel plates at the corner. In this way, the plates should facilitate uniform loading over the total surface area of the load cell, Figure 3.

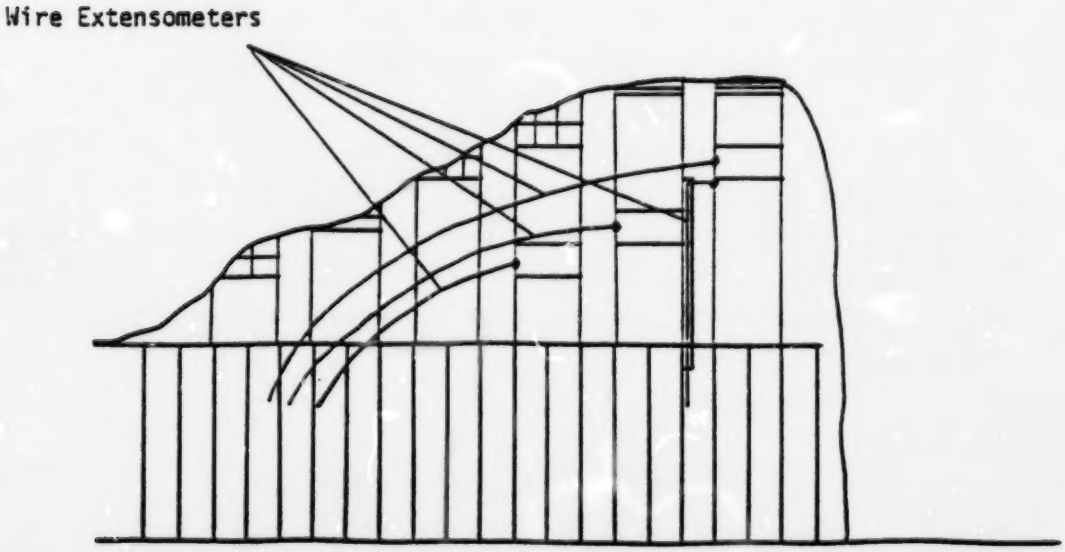
However, questions were raised concerning the reliability of the load cells when installed under the conditions described in 1) and 2). It was therefore decided to undertake a series of calibration trials using the Solinst load cells. This report describes and presents the results of those tests undertaken on one Solinst load cell using three different loading configurations.

LOAD CELL AND TEST EQUIPMENT

The Solinst load cell currently used by CBCRL is rated for 20 MPa and consists of two stainless steel plates 200 x 300 mm (8 x 12 inches) welded around their periphery and filled with mercury. The internal mercury film varies in thickness between 0.025 and 0.038 mm.



Transverse Section Through Cavity



Longitudinal Section Through Cavity

Figure 1 Schematic Diagram Showing the Instrumentation Proposed for the No. 26 Main Deep Cavity

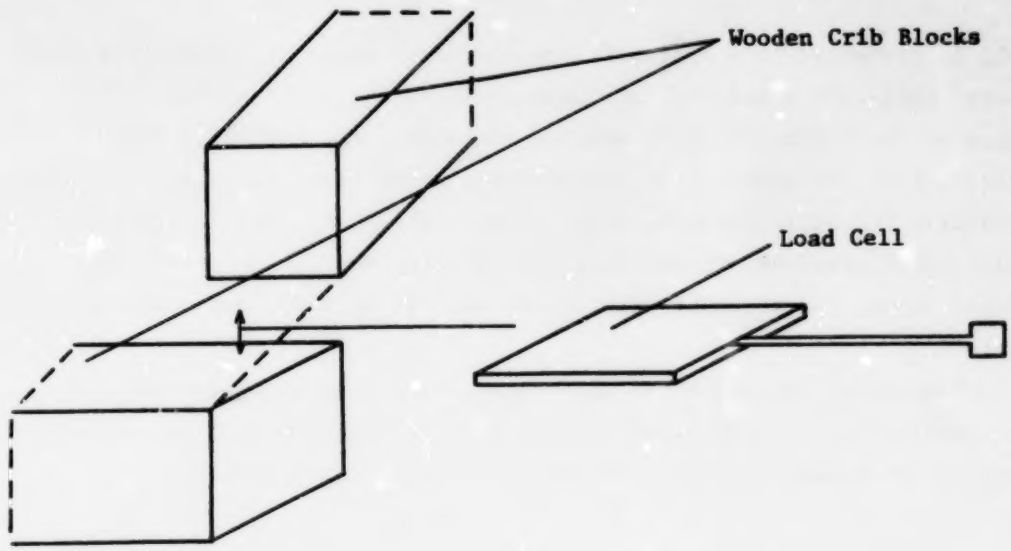


Figure 2 Proposed Insertion of a Load Cell at the Corner of a Wooden Support Crib

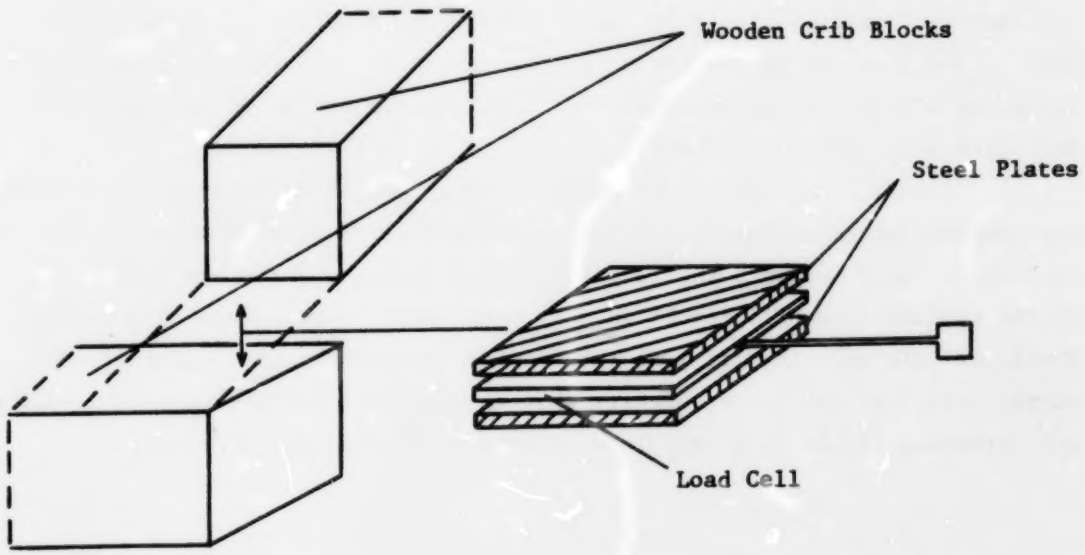


Figure 3 Proposed Insertion of a Load Cell Between Two Steel Plates at the Corner of a Wooden Support Crib

The cell is connected to a hydraulic transducer by means of a short piece of stainless steel tubing and this produces a closed hydraulic system. The principle of the hydraulic transducer is to balance the hydraulic fluid cell pressure on one side of the internal stainless steel diaphragm by means of a measured hydraulic pressure (oil) on the other. Further design and operation considerations of both the load cell and readout apparatus is considered beyond the scope of this report and has already been described elsewhere (2).

Testing of the cells was undertaken using a Dension machine with a total loading capacity of 54432 kg (120,000 lbs) owned by the Mechanical Engineering Department, University College of Cape Breton (UCCB).

CASE 1 - POINT LOAD CONFIGURATION

The first tests was undertaken to determine the behaviour of the cell under simulated point load conditions. The cell was placed on a flat steel plate 200 x 300 mm on top of which was then placed a solid steel cylinder 45.7 cm high with a diameter of 10.6 cm, Figure 4. The cell was then loaded at 45.36 kg intervals and the resultant cell reading monitored using the hydraulic readout apparatus. The results are shown graphically in Figure 5 and given in Appendix A.

Figure 5 indicates that plate closure does occur with point loading. The pressure curve begins to flatten once the applied load exceeds 670 kPa (100 psi), which suggests that a point will be reached where any increase in the applied load will result in only very small increases in cell readout pressure. Although insufficient values were obtained in the 'plateau' area, extrapolation of the curve suggests that an applied load in excess of 1.72 MPa will probably result in a cell load of between 221 and 241 kPa.

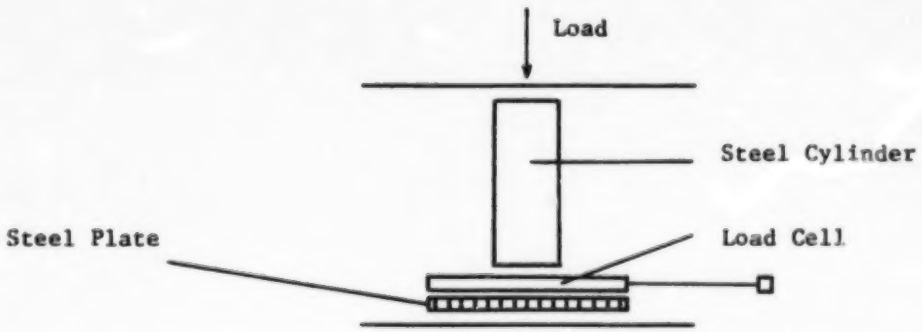


Figure 4 Load Cell in a Point Load Configuration

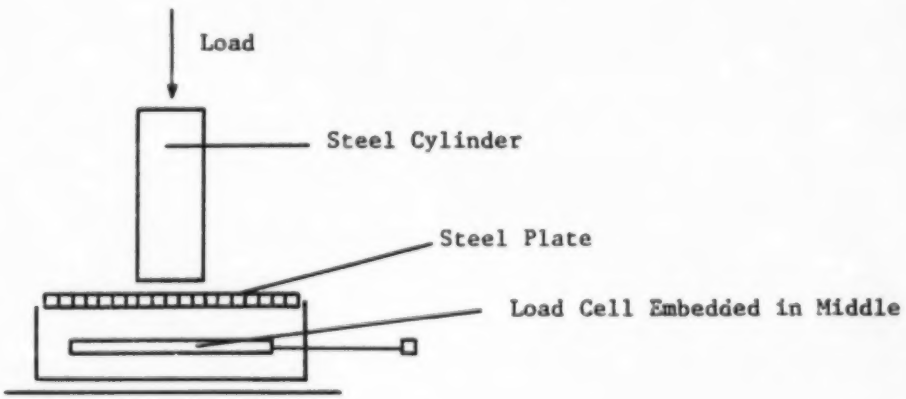


Figure 6 Load Cell in a Uniform Loading Configuration Using Stone Dust

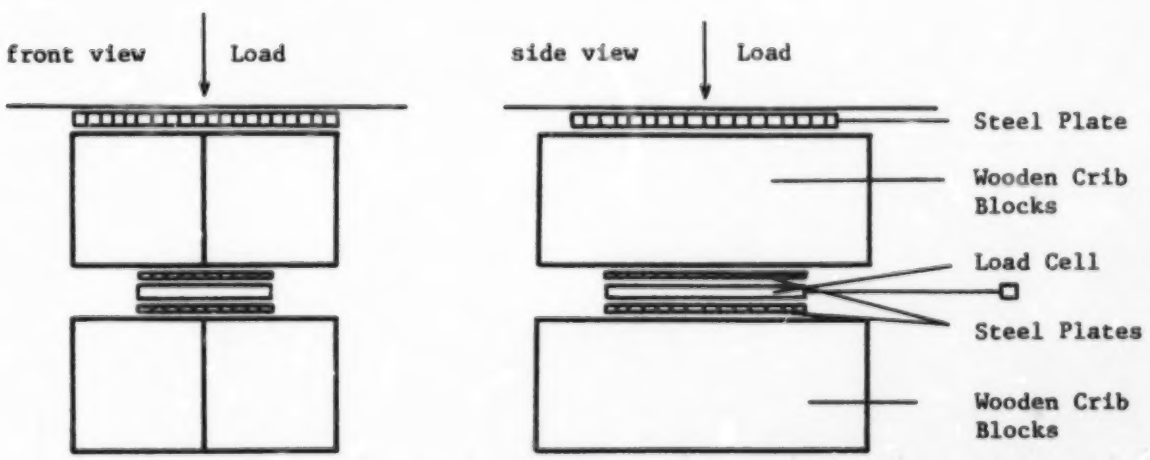


Figure 8 Load Cell in a Uniform Loading Configuration Using Steel Plates and Wooden Crib Blocks

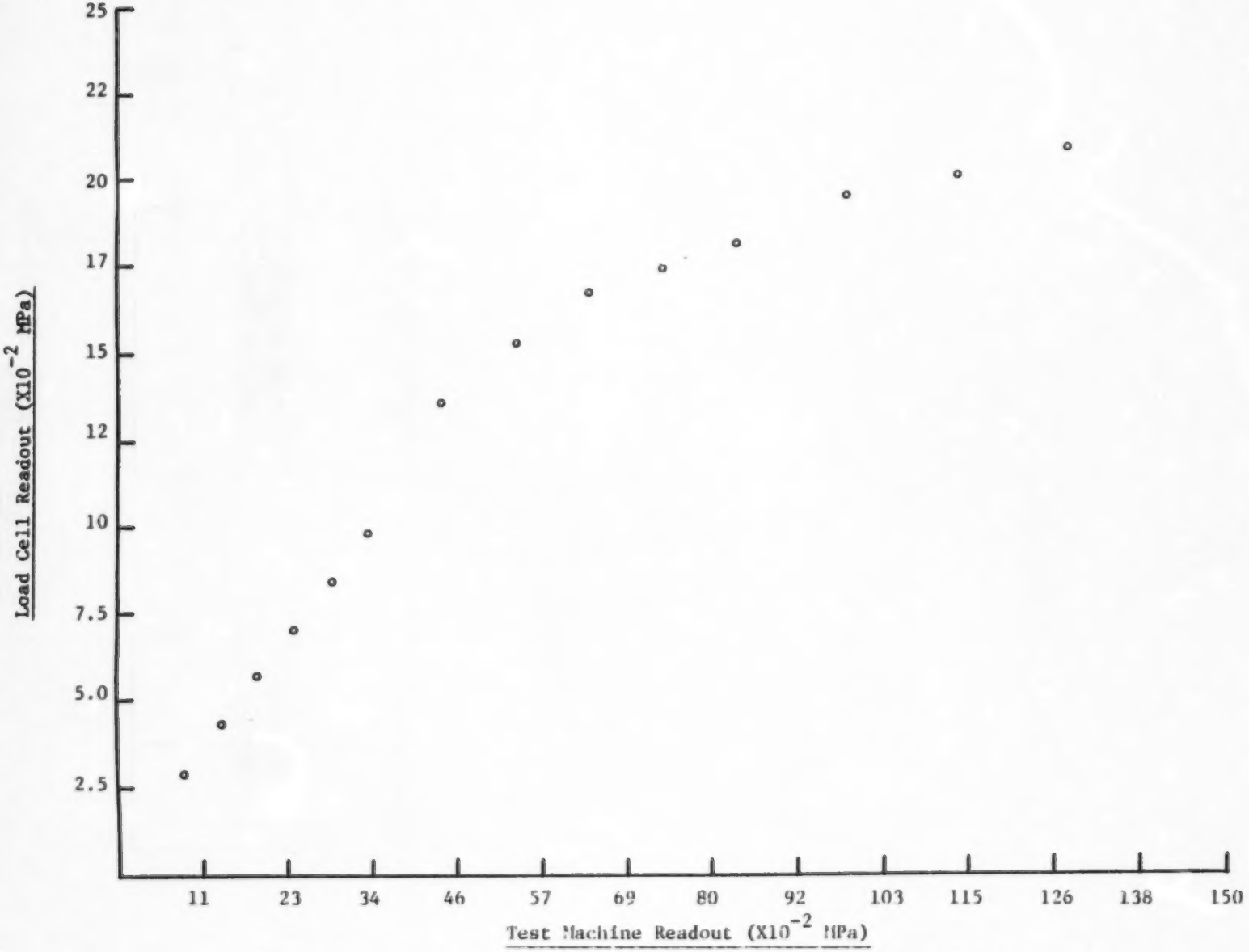


Figure 5 Load Cell Readout vs Test Machine Readout, Point Load Configuration

CASE 2 - UNIFORM LOADING USING STONE DUST

A second test configuration was used to assess the behaviour of the cell under uniform load conditions. In this case, the cell was placed in the middle of a confined stone dust layer 12 cm thick. A steel plate 30 x 40 cm was then placed on top of the stone dust layer and the load again applied by means of the steel cylinder used in case 1, Figure 6. Initially, the configuration was loaded at 227 kg intervals, although this was subsequently increased to 2270 kg intervals. At each load interval, the cell pressure was monitored using the hydraulic readout apparatus. The results are shown in Figure 7 and given in Appendix B.

In Figure 7, the applied and cell pressures show an almost linear relationship until the value of 4.8 MPa is reached. After this point, the curve appears to start to flatten out although the exact nature of the curve in this region is uncertain due to the unavailability of test results. At the point where the curve begins to flatten, two possible explanations can be put forward to explain the observed phenomena:

1) The plates begin to undergo closure across the whole surface area of the cell.
2) The peripheral steel weld starts to provide an increasing amount of resistance to further incremental loading applied to the cell.

CASE 3 - LOADING USING STEEL PLATES AND CRIB BLOCKS

The third test configuration was used to assess the behaviour of a cell mounted between wooden crib blocks. Initially, the cell was placed between two steel plates, 12 mm x 200 mm x 300 mm, which in turn were mounted between two pairs of regular wooden crib blocks, Figure 8. A large steel plate was then placed on top of the blocks to facilitate more uniform loading. The configuration was loaded at 2270 kg intervals and at each load interval, the cell pressure was monitored by means of the hydraulic readout apparatus. The results are shown in Figure 9 and given in Appendix C.

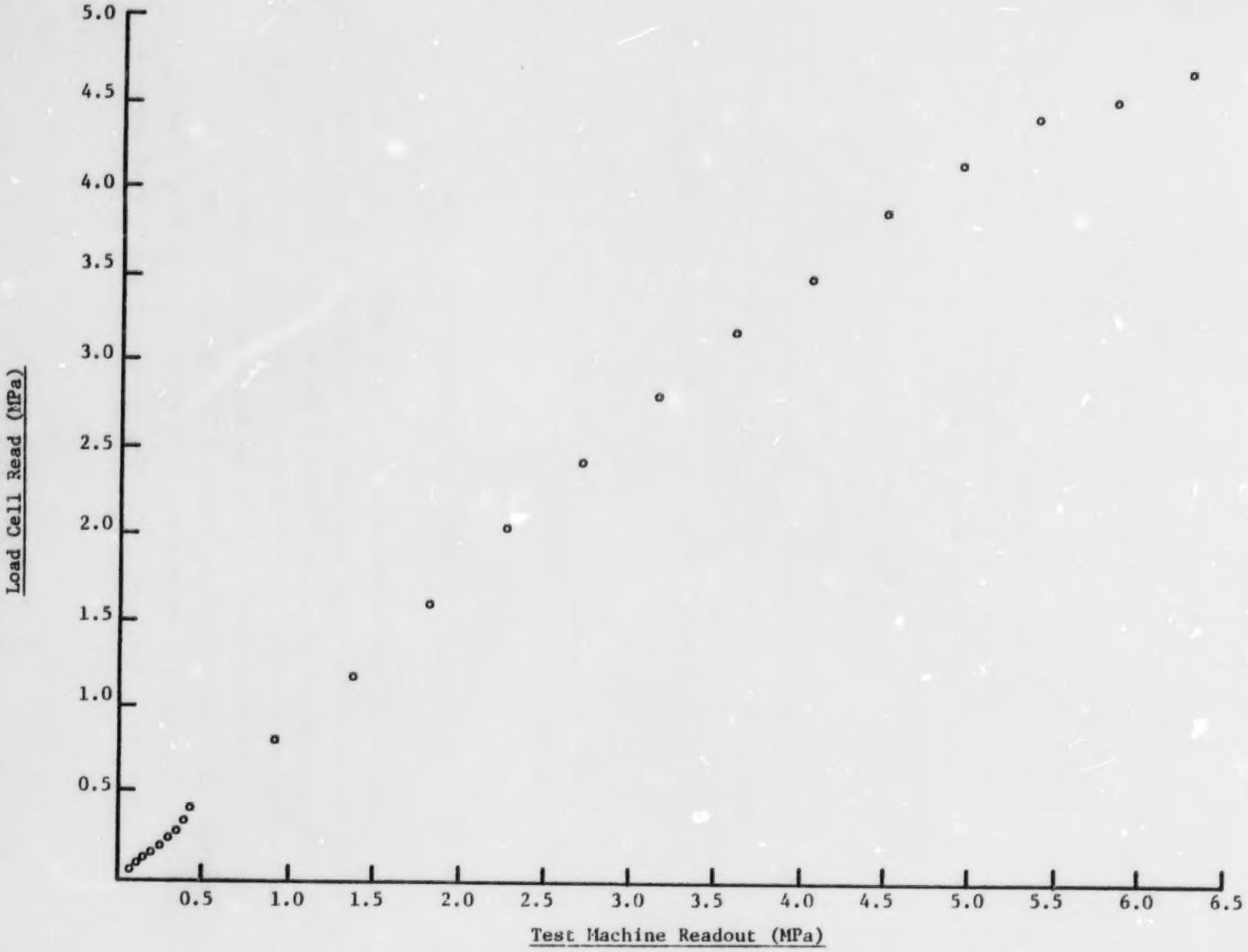


Figure 7 Load Cell Readout vs Test Machine Readout, Uniform Loading Configuration Using Stone Dust

In Figure 9, the loading curve appears very shallow until a value of 3.4 MPa is reached, when it rises sharply to 5.5 MPa and after which it begins to flatten out. A similar flattening out of the curve was also seen in Case 2, Figure 7, at almost the same applied load (4.8 MPa (Case 2) against 5.5 MPa (Case 3)). It is thought that the same reasons given in Case 2 for the curve beginning to flatten will also apply to the flattening seen in Case 3, namely:

1) The cell plates start to undergo closure across their whole surface area.
2) The peripheral steel weld starts to provide an increasing amount of resistance to further incremental loading applied to the cell.

Finally, in addition to monitoring the cell during loading, it was also monitored at 2270 kg intervals during unloading. The resultant unloading curve is shown in Figure 9 and appears much shallower for a greater length than the corresponding load curve. A shallow decrease in the curve occurs until a value of 0.86 MPa is reached, after which it drops rapidly.

DISCUSSION

From the tests conducted to date, it appears that a given load configuration will produce a definite cell response curve. However, whether the response curve is unique and dependent upon the load configuration, the individual cell or both is difficult to assess with the currently available data.

From cases 2 and 3, it appears that all the load cells should undergo calibration prior to their installation, although it should become mandatory if the load is expected to exceed 7.0 MPa.

In case 3, although uniform loading of the cell via the steel plates is assumed, it appears as though the wooden crib blocks are absorbing a percentage of the initial applied load. Similarly, although the unloading curve has been monitored the relationship between the cell and the crib blocks is much more difficult to explain.

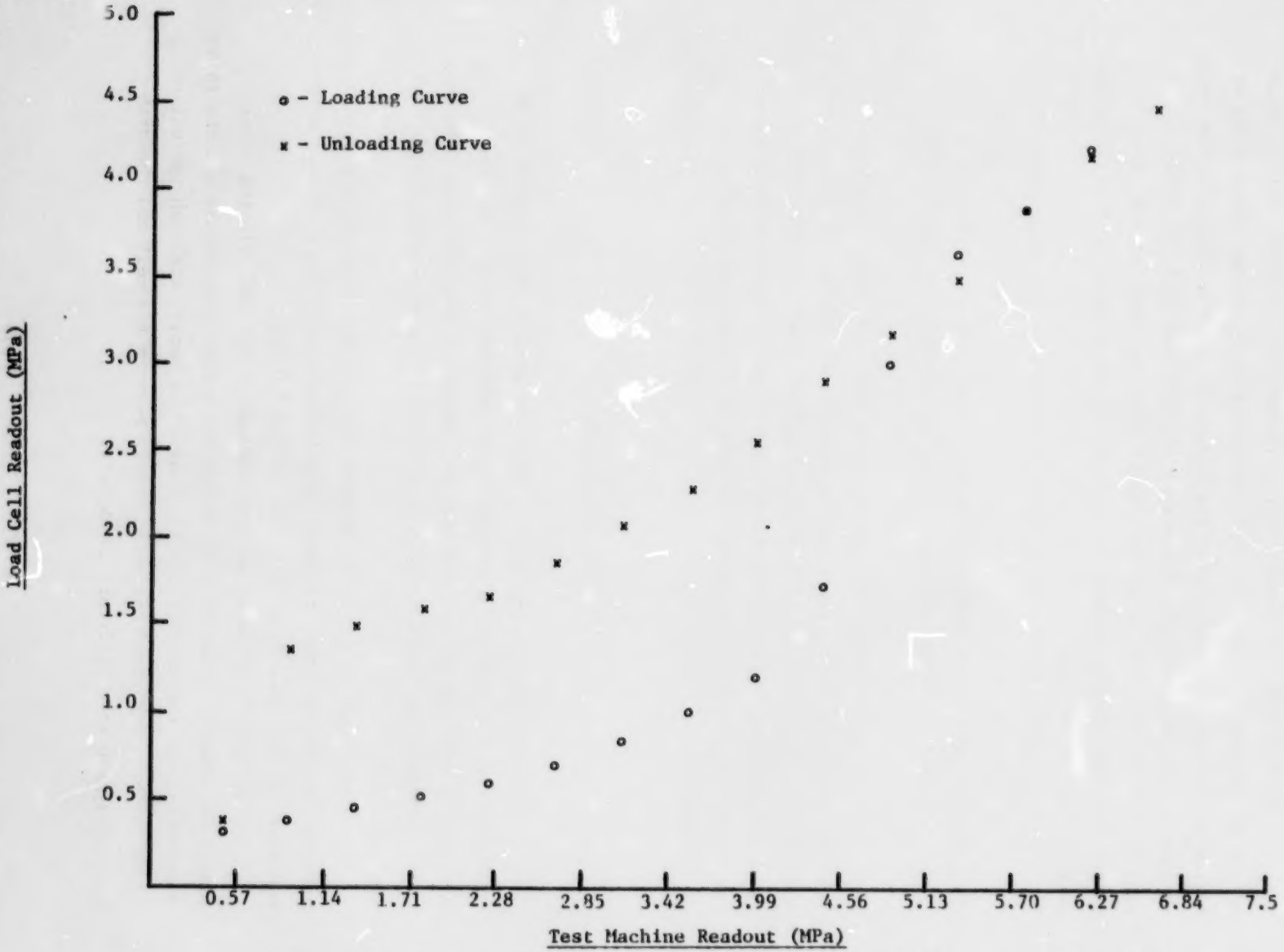


Figure 9 Load Cell Readout vs Test Machine Readout, Uniform Loading Configuration Using Steel Plates and Wooden Crib Blocks

Finally, further work on the behaviour of the cells under different loading configurations should be undertaken to:

1) Assess the repeatability of a single cell under a given test configuration.
2) Assess the repeatability of different cells under a given test configuration.
3) Determine whether the calibration method for a given cell should be dependent on the proposed method of installation.

CONCLUSION

The load cell currently used by CBCRL cannot be used to measure loads when installed in a point load configuration. Similarly, even when installed to facilitate uniform loading, calibration of the cell prior to installation should become standard practice. Finally, further work should be undertaken to investigate the behaviour and repeatability of load cells under different load configurations.

ACKNOWLEDGEMENTS

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2. Soil Instruments Limited "Pneumatic and Pneumatic/Hydraulic Transducer Equipment - Users Manual".

APPENDIX A

DATA FOR LOAD CELL IN A POINT LOAD CONFIGURATION

Weight of Steel Cylinder	31.82 kg
Area of Steel Cylinder	8.88×10^{-3} m^2

Load kg	Load Cell Readout (MPa)	Test Machine Readout (MPa)
31.8	0.024	-
77.3	0.027	0.084
122.7	0.041	0.135
168.2	0.055	0.185
213.6	0.068	0.235
259.1	0.082	0.285
304.6	0.096	0.335
395.5	0.134	0.435
486.4	0.151	0.535
577.3	0.165	0.635
668.2	0.172	0.735
759.1	0.179	0.836
895.5	0.193	0.986
1031.8	0.199	1.136
1168.2	0.207	1.286

APPENDIX B

DATA FOR LOAD CELL IN A UNIFORM LOADING CONFIGURATION
USING STONE DUST

Weight of Steel Cylinder, Plate and Stone Dust 45.45 kg

Area of Load Cell 4.96×10^{-2} m^2

Load (kg)	Load Cell Readout (MPa)	Test Machine Readout (MPa)
45.5	0.010	-
272.7	0.031	0.053
500.0	0.068	0.098
727.3	0.096	0.143
954.6	0.131	0.188
1181.8	0.162	0.233
1409.1	0.206	0.277
1636.4	0.241	0.322
1863.6	0.303	0.366
2090.9	0.379	0.411
4590.9	0.772	0.903
6863.6	1.137	1.351
9136.4	1.551	1.799
11409.1	1.999	2.248
13681.8	2.379	2.696
15954.6	2.758	3.137
18227.3	3.137	3.592
20500.0	3.448	4.041
22772.7	3.827	4.482
25045.4	4.103	4.930
27318.2	4.378	5.378
29590.9	4.482	5.827
31863.6	4.654	6.275

APPENDIX C

DATA FOR LOAD CELL IN A UNIFORM LOADING CONFIGURATION
USING STEEL PLATES AND WOODEN CRIB BLOCKS

Weight of Steel Plates and Wooden Cribs 22.73 kg

Area of Load Cell 4.96×10^{-2} m^2

Load (kg)	Test Machine Readout (MPa)	Load Cell Readout - Loading (MPa)	Load Cell Readout - Unloading (MPa)
22.7	-	-	-
2295.4	0.452	0.275	0.344
4568.2	0.896	0.344	1.310
6840.9	1.344	0.413	1.448
9113.6	1.792	0.482	1.551
11386.4	2.241	0.551	1.620
13659.1	2.689	0.655	1.827
15931.8	3.137	0.793	2.034
18204.6	5.585	0.965	2.241
20477.3	4.034	1.172	2.517
22750.0	4.482	1.689	2.861
25022.7	4.930	2.965	3.137
27295.4	5.378	3.585	3.448
29568.2	5.827	3.861	3.861
31840.9	6.275	4.206	4.172
34113.6	6.723	4.447	4.447